Space Weather Technical Forecast

Issued on Thursday, 14 April 2022 at 13:25 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1 Minor to G2 Moderate geomagnetic storm day 1 and perhaps day 2 (14th and 15th) due to CME arrival.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Very Low with no C-flares occurring, however background flux has risen to C1 at time of issue. There are three sunspot regions on the visible disc, with the most developmental AR2990 Dri/Beta, with a further bipolar region following AR2989 Cro/Beta. Newly numbered AR2991 Hsx/alpha is likely a mature and stable region that has recently rotated onto the southwest disc. No Earth-directed CMEs have been observed.

Solar Wind / Geomagnetic Activity: The solar wind, as observed by DSCOVR at L1, has exhibited the exit from one CME, and the arrival of another, likely from the filament eruption from the 11th. Solar wind speeds eased from 460km/s at first to 410km/s, before a small increase at 14/0336 UTC to 430km/s with the second CME arrival, and then a gradual climb back to 460km/s. The interplanetary magnetic field (IMF) strength Bt, was moderate at 11nt at first but gradually declined, dropped to 4-7nT between 13/2250-14/0336 UTC, then jumped to 8nT, before erratically climbing to peak 10-12nT by the end of the period. The north-south component Bz, was positive (northward) until 14/0000 UTC, peaking around 6nT, then negative (southward) until 14/0920 UTC reaching Moderate levels of -10nT, but then switched to positive (northward) peaking 10nT. The phi angle rotated smoothly from positive values (away from the Sun) to negative (towards the Sun) soon after 14/0000UTC. A sudden switch to negative values occurred at 14/0924UTC. Geomagnetic activity was Quiet to Unsettled (Kp0-3), but became Active (Kp4) since 14/0300 UTC, with a G1/Minor Storm (Kp5) observed 14/0900-1200.

Energetic Particles / Solar Radiation: The high energy proton flux (10 MeV) measured at GOES-16 at GEO was at background levels. The high energy electron flux (greater than 2MeV) was Moderate, briefly High between 13/1325UTC and 13/1425UTC and peaking at 1.42e3 pfu at 13/1350UTC. The flux then dropped out 14/0420UTC due to the CME arrival. The associated 24 hour electron fluence has been below the Active threshold throughout, with observed fluence of 3.8e7 integrated pfu bu GOES-16 at 14/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Very Low to Low. The three sunspot regions on the disc are small, and only showing limited growth, however activity from the far-side is increasingly likely to affect the Earth as it rotates near to, and onto the eastern limb.

Solar Wind / Geomagnetic Activity: Earth is likely within the CME which left the Sun on the 11th, with ongoing affects forecast day 1 and into day 2 (14th and 15th). There is still the potential for a notable flux rope (or magnetic cloud) with this CME, likely moving through during this period. Enhanced solar winds are then forecast to ease before a further enhancement from the arrival of the fast wind of CH75/+ is forecast day 3 (16th), although this is low confidence. No further CME arrivals are expected. Geomagnetic activity is forecast to be Quite to Active, increasing to G1 Minor to G2 Moderate Storm with any periods of notable southward pointed magnetic field that occur day 1 and perhaps day 2 (14th and 15th). Mostly Quiet to Unsettled conditions returning through day 2, but perhaps increasing to Active to G1 Minor Storm with any fast wind arrival, most

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likely day 3 (16th).

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to persist at background levels. High energy electron flux (greater than 2MeV) is expected to remain suppressed day 1 and much of day 2 (14th and 15th) due to the CME arrival, but potentially rising for a time later day 2 and day 3 (15th and 16th) to Moderate, perhaps peaking High. A further dropout is expected from any fast wind arrival later day 3. The associated 24 hour electron fluence is expected to remain below the Active (1e8 integrated pfu) threshold throughout, with only a slight chance of rising above day 3 (16th).

Figure 1: L1 Observed Solar winds

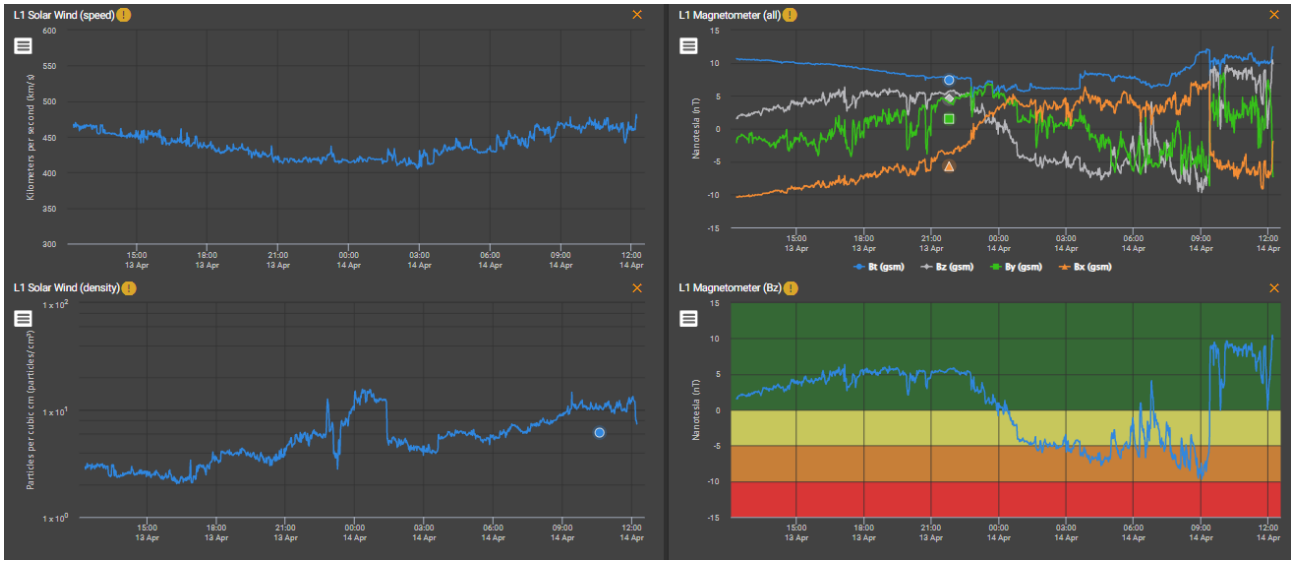

Figure 2: BGS Observed geomagnetic activity (Not yet updated, with most recent observation now Kp5).

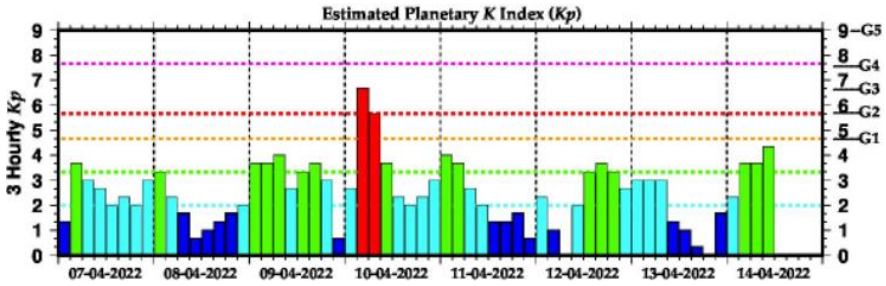

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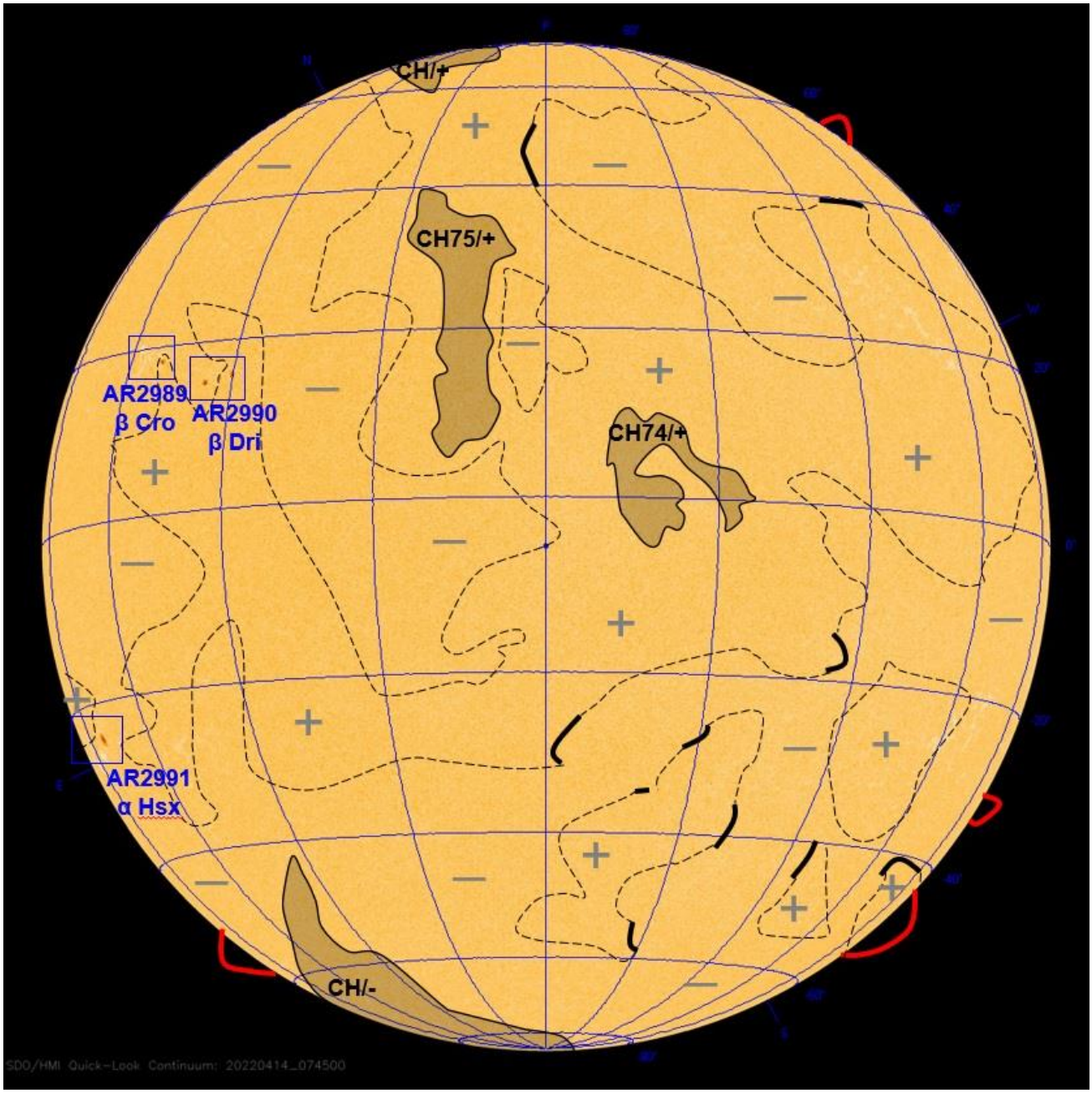
Figure 3. Solar Analysis Valid 14/0800 UTC



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The anticipated CME from the 11th has arrived early, with the initial transition into its turbulent sheath region indicated by a very limited shock at 14/0336 UTC. This has been followed by a gradual strengthening of the magnetic field, and whilst recently transitioning to a mostly positive Bz direction (northward aligned field), periods of moderate to strong negative (southward) Bz remain possible on the 14th and into the 15th (days 1 and 2) from the passing of any subsequent flux rope (magnetic cloud). No further CME arrivals are expected.

These enhanced solar winds are expected to ease through day 2 (15th), before the arrival of the fast wind of positive polarity CH74 later on day 3 (16th). The timing and strength of this feature is low confidence, with a lack no clear signal on STEREO A Mag and PLASTIC data, and also being new to this rotation, limiting the value of persistence. Furthermore, this is a positive coronal hole which is unfavoured for connection during spring (Russel-McPherron effect). Any enhanced solar winds are expected to gradually ease later day 4 (16th)

Geomagnetic activity is forecast to be Quite to Active as the Bz remains positive (northward), but likely becoming G1/Minor to G2/Moderate storm with any reversal to a southward directed field. This most likely day 1 (14th), but perhaps early day 2 (15th). Conditions then easing to mostly Quiet, with isolated Unsettled spells, but increasing to Active, with a slight chance G1/Minor Storm from the arrival of any fast wind from CH75, most likely day 3 (16th).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	100	30	20	5
Strong	G3	No	5	2	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
11/0521 UTC	Halo	Filament location	5E 5S	500	14/1200+/-6hrs	Arrived 14/0336 with minimal shock.

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Figure 4: Enlil and ensemble CME arrival earlier than enlil expectations.

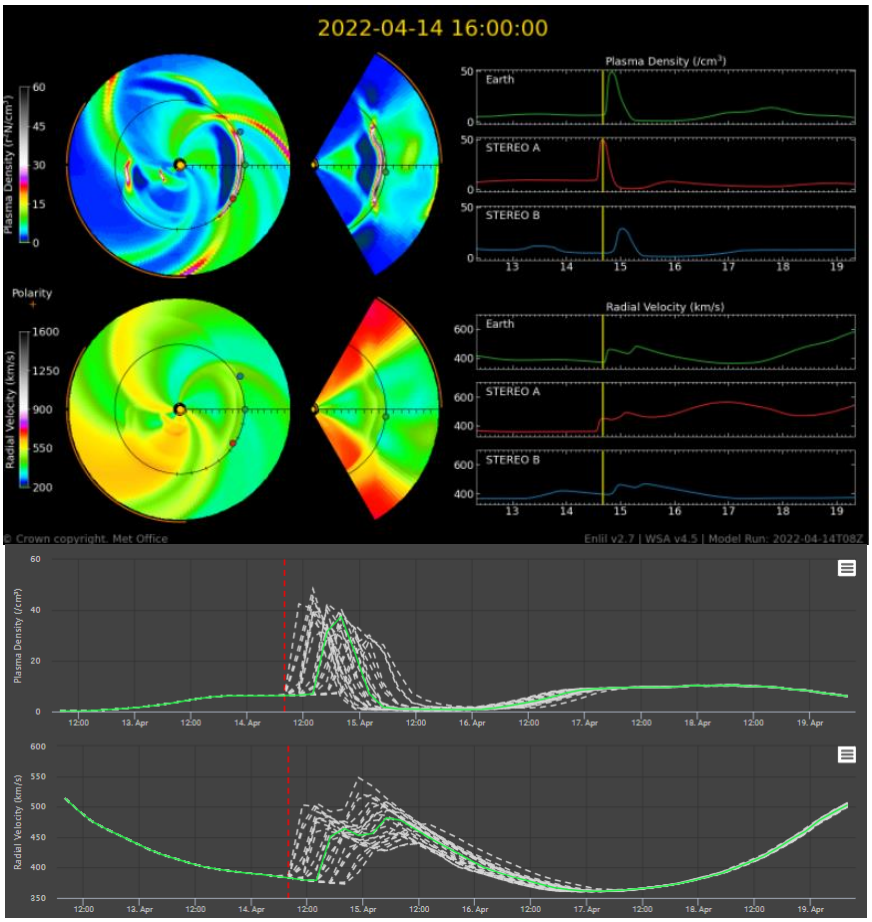
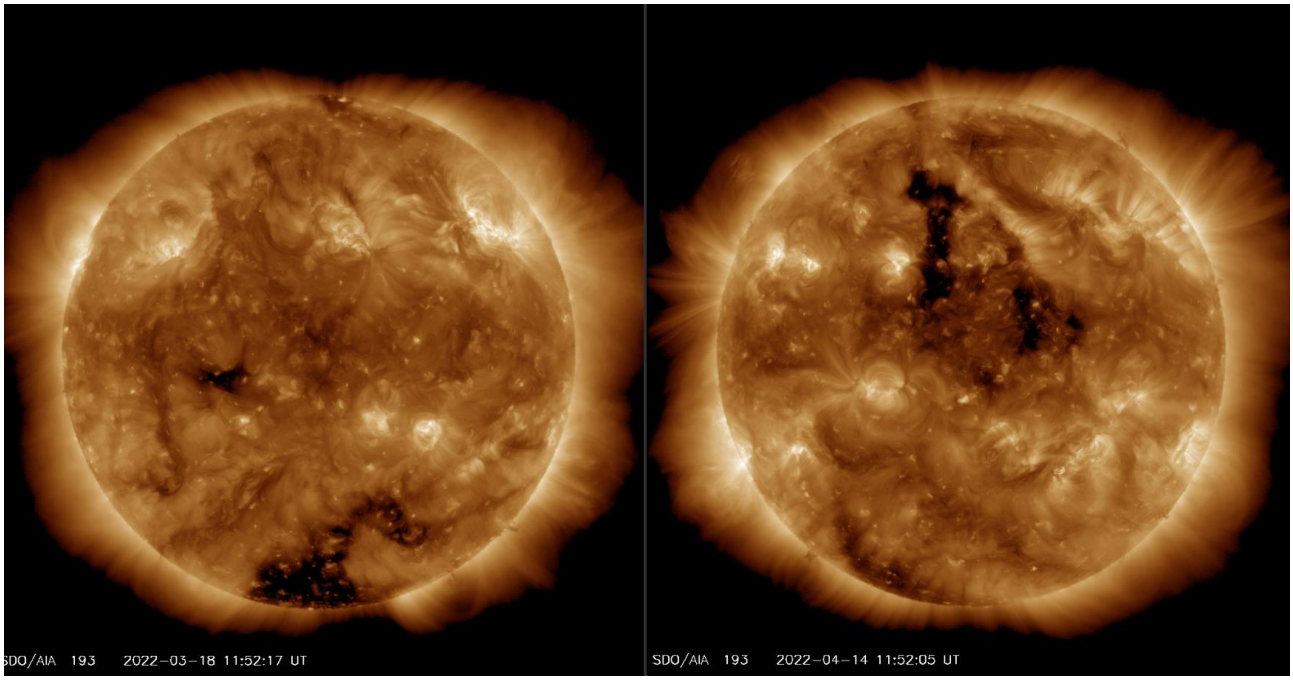


Figure 5: SDO aia-193 of last rotation (left) and current (right) CH not visible on previous rotation.



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Radio Blackouts - X-Ray Flares:

There are three sunspot regions on the disc. Whilst these are all small, and relatively simple regions with solar activity currently Very Low, some slight growth has been evident in both AR2990 Dri/Beta and AR2989 Cro/Beta, both in the northeast disc. AR2991 Hsx/alpha has also been numbered in the southeast, however this appears to be a simple and mature unipolar region. A further flux emergence in the southwest has the potential to develop into a small region in the coming hours.

The far-side remains active with recent CMEs observed, and a notable signature on far-sided products, including helioseismographs and the GONG far-side magnetograph. This corresponds to the area around AR2975 which has been traversing across the far-side, and is due back onto the east limb on the Earth-side late on day 3 (17th), and matches to a bright area of flux on visible on the STEREO A euvi-imagery. These far-side regions, alongside development on the near-side have led to background flux levels rising. Very Low to Low activity is therefore expected, however an increase to Moderate cannot be ruled out as far-side regions approach the east limb.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	2	5	5	5
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 6: GOES 16/17 X-ray Flux No flares, however background rising with far-side regions rotating on, and developing regions on near-side.

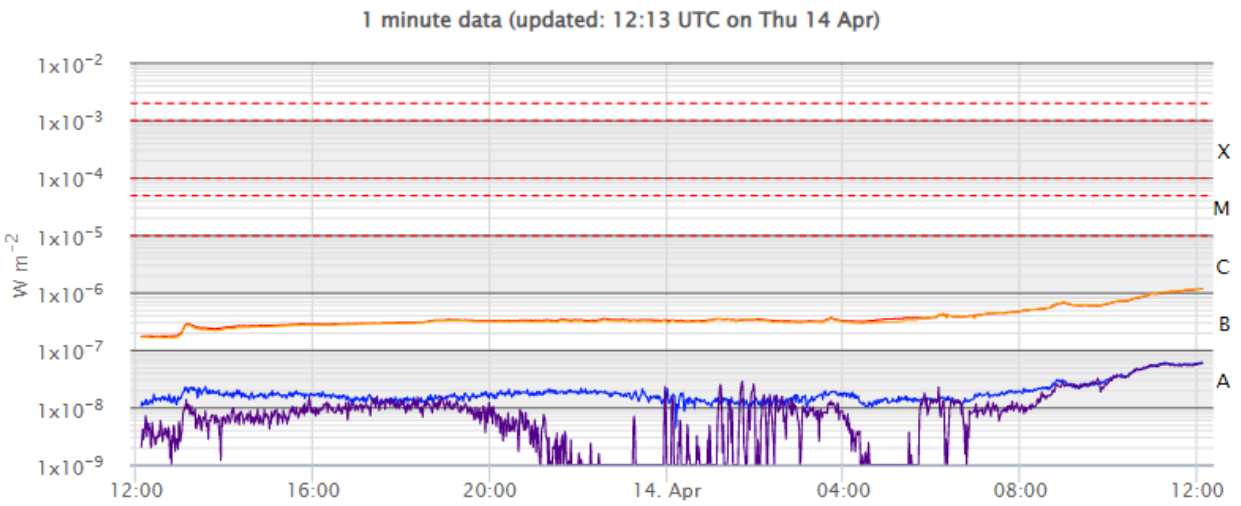

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Figure 7: GONG far-side imagery (left) and Helioseismic signal from jsoc.stanford.edu

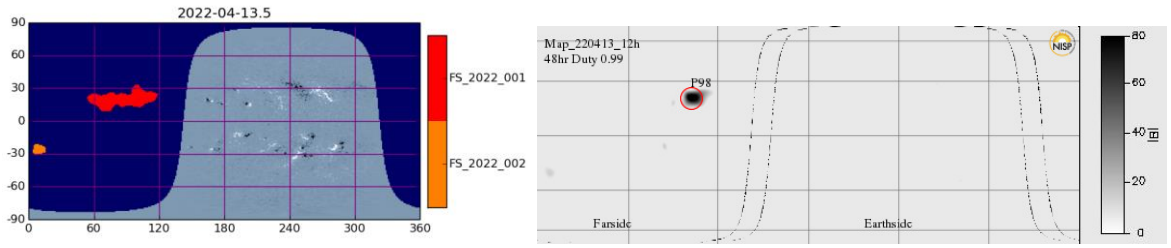
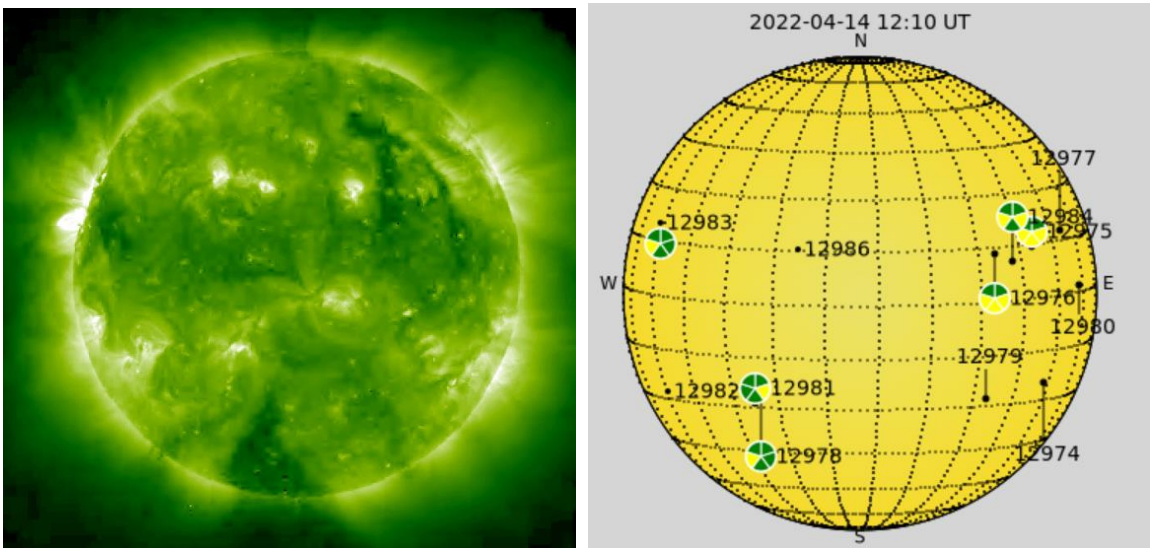


Figure 8: Stereo A euvi (left) and Raben plot showing potential regions returning



Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as measured by GOES-16 at GEO is at background and in the absence of complex sunspots on the Earth-facing disc is expected to remain at this level.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	1	1	1	1
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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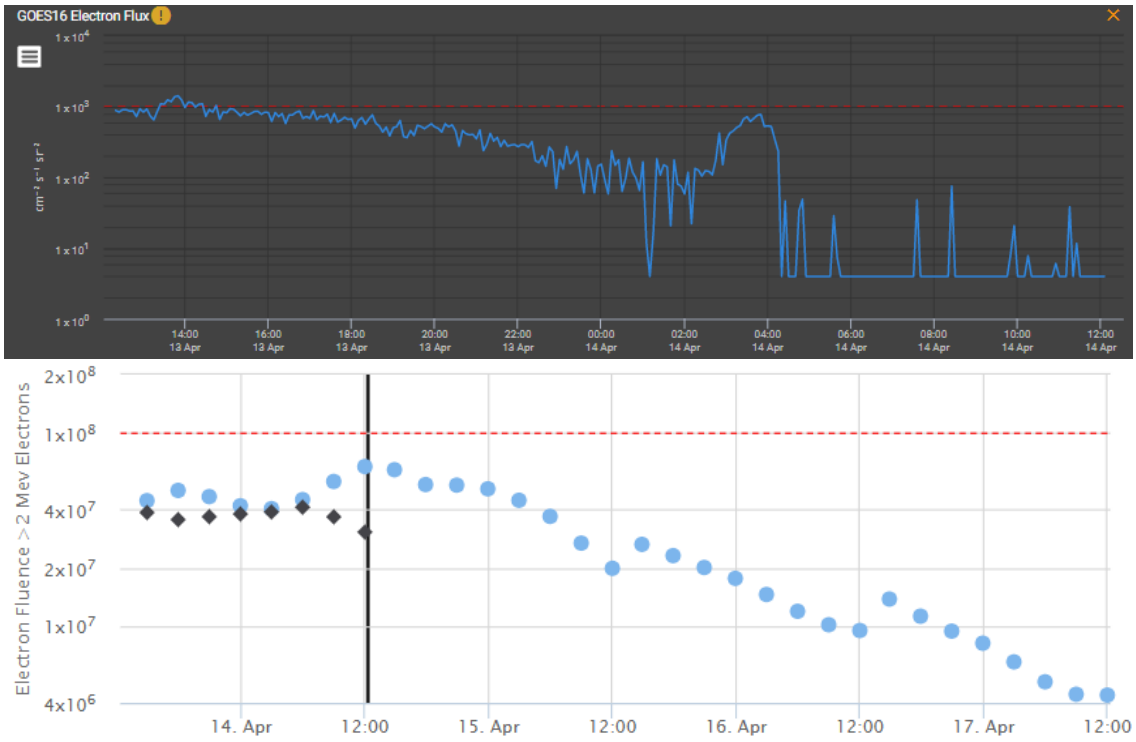
High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2MeV) as observed by GOES-16 at GEO has dropped out due to recent CME arrival. As the solar wind environment eases, the Van Allen belts are expected to relax, resulting in the observed flux at GEO to rise to Moderate, and potentially peaking at High levels on day 2 (15th). A further drop out in values is then likely later day 3 (16th), with the arrival of the fast wind of CH74, although this is low confidence in both timing and strength. A notable flux enhancement from this feature is currently considered unlikely, due to its unfavoured polarity, limited expected geomagnetic response, and the features relative immaturity with being new for this solar rotation.

The associated 24 hour electron fluence is expected to remain below the Active threshold throughout, but with a slight chance of rising above by day 3 (16th). REFM is not giving good guidance at this stage, as this currently doesn't take account of the recent CME arrival.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	10	20	10
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 9: GOES-16 >2MeV Electron Flux and associated 24 fluence with REFM



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